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THE FREE AND LIBERAL
VENTILATION OF SEWERS

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THE FREE AND LIBERAL VENTILATION OF SEWERS

In its relation to the sanitation of our dwellings

Read by MR. BAILLARGE before Section III of the Royal Society of Canada at its sitting of May 31, 1892, in the City of Ottawa.

As every thing which has to do with the well being of the human race, must be a pertinent subject of enquiry by the section of sciences: physics and chemistry; I propose to argue the question of the hygiene of our habitations as affected by the ventilation of the city sewers.

"The plan of ventilation now most approved, says the writer T. A. E. of the article "Sewerage" at page 74, vol. XXI of the last edition of the Encyclopedia Britannica, is the very simple one of making openings from the sewer to the surface of the street at short distances — generally shafts built of brick and cement — and covering them with metallic gratings."

Mr. Keating, city engineer of Duluth, Minn., formerly of Halifax, N. S., introduced the system in the latter city, and it has been carried out elsewhere; but sanitarians are prejudiced against such a mode of ventilation, labouring as they do under the false impression that openings of the sort immediately over the sewers and along the centre of the roadway, must of necessity give rise to odors and exhalations more or less disagreeable and injurious to health.

One must under such circumstances allow for a tendency to imaginary evils, as when two or three years ago, on complaint to me that a drain had burst in Montcarmel street, Québec, and that the liquid sewage running from it emitted the most offensive smell, likely to breed sickness, it was found upon examination to be a stream of the purest water running from an aqueduct service pipe to the gardner's residence on Laporte street.

Now, it is the very promoters themselves of sanitation carried to extremes, who, not understanding the question at issue, are the principal enemies of the proposed system.

I say "carried to extremes" and to proof: a host of unemployed would-be-scientists in each city, are constituted a "Board of Health", elect a President, Vice-Presidents, Secretaries, Treasurers; appoint health officers, inspectors, etc., and this galaxy of hygienists, to give themselves an air of public usefulness, prove over zealous in clamoring against the falsification of alimentary substances, in advocating the filtering of water, in conjuring up microbes, bacteria and contagious diseases, in battling for vaccination, disinfection, ventilation and the like. They fancy they are serious and in the end become so, and would convince people that a thousand precautionary measures are at present indispensable, of which no one ever dreamed in the past, and without in any way suffering therefrom.

All these subjects, no doubt, have their importance; but with due regard to common sense; and what is to be avoided is going to extremes.

The human race has already existed for thousand of years, and longevity was at least as prolonged in times gone by as it is at present. Ventilation was an unknown sciences and people did not die the quicker for it. Unfiltered water was the common beverage; and of our days, the boatmen of the Mississippi will tell you, as many of them have said to me, that they drink the unfiltered water of this river of three thousand miles in length, which every year carries down and deposits at its delta in the gulf of Mexico a hundred million tons of detritus and dirt.

At the present time, we are told that an adult should have 1000 cubic feet of fresh air to breath per hour, and some would have it as much as 2000, even three; but it is admitted that for children at school, from 400 to 600 cubic feet suffice. It is nevertheless true that one can thrive on half and even on a quarter of the quantity; for at study, respiration is quiescent, and it is so very little active during sleep, that a man is not at all the worse of having had but one tenth the quantity set forth, or as much for a whole night's rest as required during a single hour of active service — to wit: the contents of a room full, of $10 \times 10 \times 10$ feet.

But the thing explains itself when it is considered that the carbonic acid gas which man expires during day time or while waking, at the rate of $6/10$ of a cubic foot per hour and which becomes absorbed by vegetable nature and the atmosphere, is produced at night in the proportion only of the ten times less active breathing of the individual. And that it is not so poisonous as one might imagine: witness the fact that infants and others breath and rebreathe it while miffled up for hours, without the least inconvenience.

It can be shown by Herse's plan of slowly passing a given quantity of atmospheric air through a tube of which the interior is coated with beef jelly, and to which passing micro-organisms become attached and in a few days, give rise, each of them to the formation of a new colony; that ordinary atmospheric air contains some 30 germs to the cubic foot; a ventilated room not less than 30 to 900 in an equal space, and that in an unventilated school room can be counted as many as 18000 to the cubic foot—see under this head the researches of Carnelly, Haldane and Auderson at page 61 of vol. 176 of the London Philosophical Transactions for 1887—and no one will or does pretend that these microscopic organisms have not always existed or deny that they have been breathed, inspired, taken into the lungs without the least attendant danger.

Large cities date not only from to-day. The Romans, through sewers or conduits often open to the atmosphere, sent their excreta to the Sea, and they could inhale their exhalations with impunity, diluted and rendered innocuous as they were by the floods of water poured into them from their abundant aqueducts.

And let me say in one word, to have done with these preliminaries, and show that in many cases, the evil is not nearly as great as it is said to be, that while we are crying out for ventilation, nine tenths of the human race do without it and appear to be none the worse for ignoring it.

A thousand precautions are sought to be enforced in the drainage of our houses. Thousands of towns and villages, the wide world over, ignore the thing entirely and live quite as long as those who at great cost give themselves the luxury of sanitary modes of removing their excreta; and during epidemics, as during normal times, there is no more, no less sickness, there are no fewer, no less deaths in the one case than in the other.

All this on my part is to bring about the conclusion that there is not in the proposed system of free and liberal ventilation of our sewers the danger that hygienists apprehend in its bearings on the sanitation of our cities.

The advocates of sanitation, nowadays, go too far in demanding the ventilation of sewers by such expensive processes as the erection of tall chimneys here and there, and the establishment of fires or of foci of heat and suction at numerous points in every city of the old and new worlds; and the last scheme in this direction is that of MM. Peek & Hall who in a 17 page article published in the "Contemporary Review of London" for February 1892, are trying to convince the people, the authorities, that they must of necessity tax themselves to erect expensive towers here and there, wherewith to create the necessary draught as in coal mines, to ventilate the Loudon sewers, and thus as they pretend, eliminate the deleterious qualities of the London fog made noxious by the emanations from them; notwithstanding that these fogs have existed from time immemorial, and are no doubt due to atmospheric causes with which the warm sea breezes from the "Gulf Stream" may in some way be connected.

With regard to mines, and coal mines more especially, where so many dangerous and explosive gases are in constant process of formation, the thing is most essential and absolutely indispensable, and even with every possible precaution accidents do happen and will persistently continue to do so; but a sewer is quite another thing: it is under the street or roadway, not far from the surface, between which it suffices to practice openings at distances apart of some two to three hundred feet, to get rid of all the gases real or imaginary which the sewers give rise to; such ventilation having to be established, and naturally enough so, at every intersecting sewer, change of direction and difference of level of the entire system of city drainage: vertical conduits of brick work built in cement, of the full width of the sewer, by a length of say one and a half times their breadth, and being enlarged or gathered in at top or at the level of the roadway, so that each opening may when necessity dictates be used as a man-hole by which to enter the sewer, visit and scour it out as may be required; each chimney or shaft terminating at the street level in a heavy cast iron frame, rebated to receive a perforated cover of sufficient strength to allow of the heaviest traffic passing over it.

These spiracles or breathers can not be too numerous, and at 150 ft. apart the ventilation would but be the better for it, the more readily to bring about the oxydation and disinfection of the gases escaping from the sewer into the atmosphere.

It might seem at first sight that it were necessary to remove such emanations by conduits reaching above all habitations, as proposed by some sanitarians, and this would be necessary were the gases half as poisonous or pestiferous as asserted.

No, these emanations from the sewers, are by no means as noxious as they are said to be, and to proof: there are those who, so to say, inhabit them and pass their lives in cleaning, scouring and emptying them.

See the Paris Sewers : I have been in and through them on a visit of inspection lasting an hour or more, and that, in the company of a party of ladies and gentlemen from England Germany and elsewhere. The Paris sewers can be thus visited once a month under a permit to be obtained on application at the "Préfecture de la Seine", and if it does not take place oftener, except on special permission to some person of rank or who can only make a short sojourn in the city, it is that too frequent interruptions of the kind would materially interfere with the duties of those who are charged with their daily scouring out and cleaning.

True, the cess-pool system holds in Paris, and night soil or excreta do not find their way into the drains, because as an economical feature they are retained to be utilized for manuring purposes, and are during the dead of night pumped by suction into large cylindrical receptacles on four wheel trucks and driven out of Paris to be disinfected and turned into what is known as poudrette. But even if these matters did find their way into and through the sewers when freshly produced, i. e. before decomposition of them sets in, and borne away as they immediately are by the flush and rush of water from a w. c., their presence in the sewers would add but insensibly to the emanations from the urines of man and animals, domestic waters, liquids and other products from tanneries, factories, industries of all kinds, chemicals and dirt of every description which in a city of two and a half millions of souls, are every day poured into the sewers and driven through them uninterruptedly throughout the year.

Now all of us with a voice, after entering the sewers at the "Place de la Madeleine" and emerging from them at the other end of Paris, all of us I say agreed in admitting that the most delicate olfactories had experienced nothing disagreeable; nothing more in a word than a slight sensation of closeness as on entering a bedroom in the morning or a house for some time untenanted.

And why no smell, nor anything approaching even to it : the sole and abundant supply of water poured into the sewers from the street hydrants opened every morning to cleanse the gutters or water channels of the balance of the dust swept into them, after removal — during the early morning, and before the shops and stores are opened — of the bulky material — scraped and swept together into heaps during the small hours of the night — to the city dumping grounds, in tumbrels provided by the municipality.

The waters already alluded to, as well the waste from taps and other sources, and occasionally those from rains and storms : all these together, run along as a tiny river at the bottom of the sewer, in a channel eight feet wide and some 4 feet deep, formed in the "Grand Collecteur" of 16 feet in width and 10 feet high, under the rue de Rivoli, by the double 4 feet cut stone side walks on which two men on either side trot along and thus by means of a projecting bar propel the boats containing the excursionists.

The sewers of secondary size, which empty their contents into that just described are only 10 feet in width, with a six feet channel between sidewalks two feet wide, and on either side thereof is laid a rail along which a series of cars, again propelled by hand by men told off for the purpose, one on each side the channel, ride smoothly along above the flowing waters. The sewers, third in point of size are six feet wide with a side walk on one side only; and one and all of them are thoroughly lighted up with gas or oil and will now shortly be, if not already done, by incandescent electricity.

The quantity of water in the sewers is such as to dilute, in the ratio of say 100 or 1000 to 1 every particle of absolute sewage or excreta passing through them and which might otherwise prove noxious ; and they are absolutely without danger to the host of employees who may be said to pass their lives within them

†. Fifty or a hundred years ago I would not have suggested what I now favor for cities and towns in general; but where at present is the community of any importance in the old or new world, which has not its aqueduct, its abundant supply of water; and in such abundance as to be in bulk a thousand or ten thousand times that of all the filth to be removed and such as to render it absolutely inoffensive, as far as any smell or noxious gases from it are concerned.

Like Don Quixote who created wind mills, then to war against them ; it is that terrible word "sewer gas" which after thus wrongly styling it, we are afraid of and endeavour to combat by the most expensive means, in no way called for and out of all proportion with the evil to be done away with.

"Sewer gas" is nothing more than ordinary atmospheric air slightly contaminated by

its admixture with the gases which are formed by the decomposition of the sewage matter, as well by the organic germs which these matters hold in suspension : microbes and bacteria, etc.

It is equally certain that the would-be-dang'rous character of these gases, is reduced if not entirely eliminated by their free exposure to the oxydizing action of the air. A more serious danger is that in certain cases of sickness, these products are charged with specific germs, and require to be promptly destroyed or removed by gravitation after being sufficiently diluted with water.

The gas called "Sewer gas" has no existence, or at least it does not necessarily exist or in spite of our endeavours to prevent it ; and if it does exist, it is because we will it so, since it is so easy to get rid of it, or rather to prevent its formation by conducting it immediately and continuously into the atmosphere by the proposed ventilators along the centre of each street and as already stated directly over the sewers to be disinfected. Once more this gas is nothing but atmospheric air which under its normal and ever active pressure, penetrates the sewers as it does our houses and our lungs.

I have just said that the liquid and solid excreta, when freshly produced and undecomposed are absolutely inoffensive, with the exception of those of certain diseases, but which mixed with normal excreta or of persons in health, rarely count for more than one in a thousand or even in ten thousand, as at present in Quebec for instance where there are, or were at the time of writing this, eight cases of diphtheria to a population of 80,000 souls.

These excreta, I repeat, are inodorous, innoxious while in the water in which they were deposited, and continuing their course in full water towards the sewers and in full water through the sewers and until their expulsion into the river, lake or sea, as the case may be, and the time of this trajectory or passage to an outlet, not generally more than an hour or two in riparian cities like Toronto, Montreal, Quebec, Ottawa, Hamilton, etc., or cities through which rivers pass as in the case of London or Paris, etc.; decomposition does not set in during such a brief period of time, nor would it do even if the time of passage were many times as great.

Another proof that these substances are inoffensive is that it has been demonstrated that the fears entertained that sewage-irrigated lands would prove detrimental to health, have been entirely dissipated, their sanitation being entirely effected by the oxydizing power of the air.

Admitting now for an instant, that human excreta do under some circumstances prove slightly disagreeable to the olfactories, they are not for all that the more noxious in a sanitary point of view when of recent production; no more than are the fumes of a variety of substances which without being agreeable to the sense of smell, as of coal oil for instance, are none the more deleterious for that.

I therefore conclude from the premises recited, that for any city having an aqueduct and a regular and proper system of drainage, that is to say: sewers of proper ovoid section, and therefore narrow at the base or invert, so that the water may flow through them under as great a head or depth as possible, and with an inclination proportional to the depth of water; such sewers can be ventilated in the way set forth, without giving rise to emanations in the slightest degree anti-hygienic, or even more pestiferous, than those of every day life which we cannot escape, as of the excreta of horses and the like.

It is moreover known that a rapid or active run of water in a sewer, creates a friction at its surface which drags along with it a certain stratum of air, which in its turn gives motion in the same direction to a second stratum, this to a third and so on until the whole body of air above the water in the sewer is set in motion towards the outlets of the system and thus expelled; contributing thereby in a considerable degree to effect the ventilation of the conduits.

But if I thus insist on the ventilation of sewers, it is not so much on account of the sewers themselves, and of those who have to attend to them, as for the purpose of thereby rendering our habitations safe from what might become "sewer gas" in unventilated sewers; for no other odors, no other gases can find their way into our houses, than from the public drains; and notwithstanding every precaution to the contrary, the barriers will be some times broken, and contaminated air will jump the seal under the pressure of waves and wind and rising tide at the plenum state of the air in the sewer will exist and therefore an increased pressure, or greater than that of the air within, and such pressure will overcome the slight head of water in the trap and penetrate beyond.

It must be remembered that it requires quite a trifle to force the seal of the S pipe or double siphon, or of the trap so called. Generally there is but a depth of from one to three inches

of water to be overcome. A pressure of only $4\frac{1}{10}$ of an ounce will therefore suffice to force the inch of water, $1\frac{1}{5}$ ounce the 3 inches, and if any one will take the trouble to look at a barometer and see the three inch play of mercury allowed for— $1\frac{1}{2}$ lb. in the pressure or $\frac{3}{4}$ lb. below the normal and $\frac{3}{4}$ lb. above—and consider that one can hardly appreciate or feel the difference; an idea will be had of the imperceptibility to our senses of the very slight increase in pressure capable of forcing the seal of the valve or air trap.

And that our senses are too blunt to appreciate such slight differences of atmospheric pressure is also made evident by the fact that it is only when Gay Lussac and Biot & Arago attained in their ballooning expeditions such a height as to have left almost one half of the total weight of the atmosphere beneath them; only then it was that they became somewhat painfully aware of the difference of pressure within them and without, and in the same way again as men can work under a pressure of several atmospheres, and pass from the plenum to the outer air, or vice versa, as from a comparative vacuum to a plenum, through the intermediary of an air lock with a simple tap at top and bottom to gradually bring about the change of pressure.

But the seal in air traps gives way before other causes than that of difference of pressure on opposite sides of it; as by capillarity when the fibres — so many minute conduits — of a rag or fragment of a towel arrested on its way and bending over the lip or crest of the dam while reaching to below the depth of seal on one side and to a depth a little greater on the lower side, gradually draw off the water from the trap and leave the siphon open to the passage of the gases.

It also happens that during vacation, with the family in the country and the house shut, the water in the trap becomes evaporated and thus again allows the foul air to pass from the sewer to the house; or it may be a sudden flush of water, which momentarily held in suspension by an obstruction, as of paper, in the soil pipe, when the chokeage gives way before the pressure of the column, so suddenly precipitates it-self into and through the trap that with the *vis viva* of the velocity acquired, it jumps the boundary without leaving any of itself behind, or if any, too little to reach the apex of the dam or high enough to seal the siphon.

Whence it is evident that the most perfect seal of the so called air-trap or barrier between the house and drainage is but an inadequate mode of shutting out the atmosphere of sewers. And it is because this fouler atmosphere of drains can not fail now and then to force the seal and find its way into the house or dwelling, that I favor the scheme of the free and liberal ventilation of these conduits of excreta, their direct communication with the outer air to prevent the formation of gases which otherwise acquiring intensity with age, would or might become and under the present unventilated system, do become noxious and possibly even poisonous and therefore destructive of health and happiness within the dwelling.

For with all the precautions of house-wives, and in many cases due to their very negligence and more especially in pauper tenements, or in those run up by the dozen by parsimonious landlords and where sanitary appliances are wanting, vegetable and animal matter may and do find their way to the sewers; that is to say putrescent matter or subject to putrefaction, the hydrogens from which, amonias and acids forming but slowly can not acquire undue intensity when by the ventilation proposed, these gases escape and become mixed with, diffused in the outer atmosphere, before they acquire any smell or odor of a nature to cause them to be pronounced, not poisonous but even as much as only slightly disagreeable to the most sensitive organs of smell.

I have said that the sewers should be made of ovoid section or pointed, with the narrow end down, and this holds especially where but little water passes, so that this water may attain as great a height as possible in the sewer, which will float the solids, hasten them along and scour the pipe continually. Moreover, the solids decompose more slowly when in water or if they do the contrary, the water imbibes the gases and renders them harmless.

This question of the depth of water in ratio to its width of stream in the conduit, makes it imperative also that for house drainage and other, the pipes be of the smallest diameter possible. This has long been fixed for service or soil pipes from water closets at 4 inches in the interior of houses; not does it require to be of any greater size without, or between the house and street sewer: for while the scouring water, which runs through the pipe at each flushing of the pan, fills the 4 inch pipe to a depth sufficient to remove the solid excreta, it is evident that in a pipe of greater diameter, as 6 or 8 inches, the same quantity of water, and it cannot be any more abundant, coming as it does from a vessel of fixed capacity — the 3 to 4 gallon service box or cistern as it is called — cannot wet the bottom of the larger pipe to such a depth; or to much more than half the depth it does in the narrower pipe; which rendering the flow or current less rapid, from the

broader friction area, the solids instead of floating at the surface as in the 4 " pipe, touch and drag the bottom and coming in contact with, for instance, an excrescence of cement forced from the joint by driving home the pipe, adhere to it, become dry and hard before a new flush follows to help remove the obstacle and during such sojourn of excreta in the pipe, emit gases which with age become deleterious, if even they do not in course of time cause the complete obstruction of the pipe, as often happens and thereby grave inconveniences, impediments to sanitation and withal, the expense of a plumber to remedy the evil.

It therefore pertains to sanitarians and others to combat this erroneous idea on the part of proprietors and ignorant architects who believe in and advocate the use of larger pipes as less liable to chokage, while on the contrary they are doubly so, and that the too shallow water in them leaves behind it matters which become injurious to health, instead of removing them immediately to the main or street sewer which hurries them off to the outlet; for if not, these matters thus arrested half way disengage while in their dry state gases which have no tendency, even with the main sewer well aired and ventilated, to get there; since on account of the higher level of the soil or service pipe, and the higher temperature of the freshly produced matter, the tendency of the gases is to rise still higher and to penetrate by a defective air trap or the absence of any such preventive apparatus, into the interior where the air rarefied as it generally is by a temperature above that of the outer air or sewer, produces a partial vacuum and with it a suction inward of the emanations mentioned.

I may say and as bearing on the subject at issue and the sanitation of houses, that in any building the closets should as much as possible be placed one above the other in the different flats, so as to discharge immediately into a vertical conduit, rising directly from the cellar pipe to the very summit of the house or edifice and through the roof thereof. This pipe, the higher the better above the roof, should terminate in a cowl of a shape to allow the wind in its generally horizontal motion to create therein by suction a partial vacuum and therefore a rising current most effective in the elimination of such gases as may arise from excreta on their way to the sewer and from as far down as the air trap between the house and outer drain; while not forgetting neither that one of the advantages of such a pipe discharging high into the atmosphere, is, should the seal of the air trap fail below, while that of the traps beneath each basin remain unbroken, to allow the sewer gases a mode of escape through the roof without in any way endangering the well being or comfort of the inmates.

I have already said that the water in motion in a sewer, that is by the friction at its surface, causes a current of air, or rather sets in motion by dragging with it the air within the sewer, a fact well known to those who have to do with these underground conduits and which may be noticed at the outlets. In the same way, when other means are wanting, can a draught be created in a ventilating pipe or conduit or a flue, precisely as with the "Injecteur Giffard" a jet of steam can be made to drag along with it a current of water into a steam boiler to replenish the supply.

There can be no spontaneous ventilation, no current, no motion in the absence of some stimulating process: some, heat, force, or friction to bring about the same, and that, notwithstanding all the possible conduits and however well disposed to the effect desired; and there can be no heat, no difference of temperature without some calorific influence, some heat creating power, as when the sun in summer makes the outer air warmer than the inner or a fire within raises the temperature of the house or habitation to a point above that of the surrounding atmosphere.

There must be a force to overcome the friction of the moving air against the sides of the conducting tubes. To create one it suffices to remember that when an idle chimney flue, can therefore not be utilized, there always does exist the very simple process of propelling away the air to be got rid of, by building a fire within the chimney flue, as in the fire-place, grate or soot door at its bottom or even in a stove pipe hole at any story on a piece of sheet iron suitably disposed to effect the desirable object, or in a flue adjoining, or the more expedient, though possibly more costly method of one or more jets of gas, or even a coal oil lamp set in a flue and left to burn therein while at the same time through an open and glazed aperture doing duty as a light in the apartment.

And if the burning jet of gas or lamp be overhead and intended to ventilate the room where it is doing duty, it should be disposed beneath a funnel like cowl which will collect the vitiated air and through a tube of proper size convey it to the flue or conduit for expulsion.

To, so to say, exhaust the subject of aerating, airing, ventilating and though it have no direct bearing on sewer ventilation; but as a mode of arriving at one of the effects of ventilation, viz. the freshening or cooling of the air within a building; I may say that in the same way as the sprinkling of streets, that is, of the roadway and sidewalks, brings about a marked reduction of the temperature, under the action of evaporation of the water which to become vapor robs the air of and thus lessens its heat; in the same way can we cool our houses by allowing a stream of water to flow by gravitation through a pipe to the summit of the roof whence it can be by a perforated tube made to run like rain from the ridge or saddle of the roof, down the sides and thence fall from the eaves.

This artificial rain would in its tendency to evaporate, rob the air of its excessive heat and thus reduce its temperature, or a current of warm air flowing or blowing towards the house, with a tendency to enter, would thus at the threshold of a door or window be cooled down before it reached a person sitting in the interior, in the same way as during a summer shower the air which reaches one on a veranda feels most agreeably cooled down by the phenomenon; and in the same way also as a warm breeze reaching one after passing over and licking the surface of the ice in the family supply van as it goes along the street from door to door, deliciously fans the face of any one encountering it, and suggests the idea of how a similar result can be brought about at home by so disposing a set of perforated shelves covered with ice, or a set of pipes filled with ice cold water in a gallery along which the outer air can be made to travel and cool itself before entering the house, or by a series of jets of water so disposed as to cool the air by evaporation as already stated.

To return now to my subject of the ventilation of sewers as affecting the hygiene of our habitations, I have to say that an additional and pertinent reason for ridding them of their vitiated air and thus deharring the latter from penetrating to the interior, is that of preventing the compression of the air in the sewers, as often happens during the year, by sudden gusts of wind, or by persistent winds blowing up the sewers, or by the impulse or sudden action of waves, as well by the rising of the tide and the consequent closing of the outlets; and it is then especially, a thing of every day and of twice a day in tidal waters, that the great advantage of the proposed ventilating shafts becomes apparent, acting as they do as so many safety valves by which the compressed air can escape into the outing, thus preventing it from increasing its pressure in a way to force the seal and get within the building.

The free and liberal ventilation of our sewers would therefore have the effect not only of ridding them of their gases did such exist; but, if any such were formed, of not giving them the time to intensify and become noxious before being expelled into the ocean of air which envelops the Earth to a depth of may-be 50 miles and of which the volume if it were reduced by pressure from above to that which would give it the same weight per cubic foot throughout (say about an ounce at sea level) would still be some fifty times that of all the seas and oceans, lakes and rivers of the world, and which under such a volume would more surely and abundantly dilute the gaseous emanations from the sewers, than can the less abundant waters of the earth dilute and render harmless the liquids and solids, the whole body of sewage which ceaselessly pours into them and has been doing so since man is man.

I would also remark that exhaust steam from engines, boilers and the like should not be discharged into the city sewers, as it not only causes the rapid destruction of the brick work or masonry thereof by constant alternation of heat and cold; but has also the injurious effect of hastening and aiding the formation of miasmatic gases by accelerating decomposition of putrescent substances, and by so increasing the pressure of the air within the sewers as to enhance the risk of forcing the seal of air traps in a way to give passage of the vitiated air to the interior.

The author of the article on "Ventilation" in the British Encyclopedia, and to which I have already referred, alludes but briefly to the ventilation of sewers, but at sufficient length to say that the free and liberal ventilation of sewers, by a system of air shafts at short distances along the line, is admitted to be the system most in favor now with engineers of experience, and I hope I have demonstrated to the satisfaction of all, and of even every sanitarian, that the system is the only one which can cope with every difficulty and conjure all objections, all the danger presently existing of the irruption of miasma into our houses, accompanied as they may be by microbes, bacteria and other organic germs of such zymotic and contagious diseases as small-pox, typhoid, diphtheria etc.

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